THE FACILITATION OF PROBLEM SOLVING AND VERBAL CREATIVITY BY EXPOSURE TO PROGRAMED INSTRUCTION[1]

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Numerous investigations have demonstrated that problem-solving skills and creative thinking can be facilitated through training or instruction. A variety of approaches have been used; e.g., eliciting uncommon responses in free association (Maltzman, Bogartz, & Berger, 1958), brainstorming (Meadow & Parnes, 1959), and enrichment of regular classroom curricula (Torrance, 1960). Recognizing that programed instruction has great potential for the training of high-level cognitive skills, there has been considerable interest in the possibility of utilizing this potential for improving problem solving skills and creative thinking.

Given the distinguishing characteristics of programed instruction, the use of this pedagogical technique to facilitate problem solving and creative thinking would seem futile. Indeed, one might conclude that programed instruction has potentially detrimental effects on creative thought and performance. It has been argued, however, that by avoiding overly strong commitment to rigid forms of programing and by inventing new programing techniques that are positively adapted to the requirements of creativity training, it is possible to use programed instruction to improve problem solving and creativity (Crutchfield & Covington, 1965). Using special forms of programed-instructional materials designed to improve problem-solving skills and creative thinking of fifth- and sixth-grade pupils, Covington and Crutchfield (1965) report significant gains for an instructional group as compared with a noninstructional group on three types of criteria—paper and pencil problem-solving tasks, paper and pencil tests of divergent thinking, and attitude and self evaluation measures.

Because of the relative brevity of the programed-instructional material, Covington and Crutchfield believe that it acts primarily to sensitize the pupil to the use of skills he already possesses rather than to help him develop new problem-solving skills. Further, they note that their results support the notion that there is a great degree of generalization of the skills strengthened by the program. Persuasive evidence is offered for the feasibility of the direct training of generalized problem-solving skills which are relevant to the thinking processes of the individual in a wide variety of situations.

The study reported in this paper examined the effects of an adaptation of the Covington and Crutchfield programed-instructional materials on the behavioral problem-solving performance and verbal creativity of eighth-grade students. Paper and pencil tests of imagination, flexibility, originality, and fluency were used as measures of verbal creativity. The Maier Two-String Problem (Maier, 1931) was used as the measure of behavioral problem-solving performance. It was expected that *S*s in an instructional-treatment condition would perform significantly better than *S*s in a noninstructional-treatment condition on both types of measures.

It should be noted that the present study differs in several important respects from those reported by Covington and Crutchfield and other studies of attempts

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to facilitate problem solving and creative thinking. First, the Covington-Crutchfield research is extended by using similar programed materials and criteria of verbal creativity with eighth-grade students. Inasmuch as the facilitative effects produced by the program appeared to be stronger at the fifth-grade level than the sixth-grade level, Covington and Crutchfield suggested the need for developing more advanced and/or differently oriented programs for students at higher grade levels. The present study, using eighth-grade students as subjects, contributes evidence bearing on this suggestion. Second, it is noted that existing studies of creative performance after exposure to training have, in the main, employed paper and pencil measures as the only criteria. The two-string problem was used in the present study to test whether or not instruction in verbal creativity would transfer to a behavioral measure of problem solving. Specifically, a test of the Covington-Crutchfield hypothesis regarding the transferability of direct training of generalized problem-solving skills is offered. Also, Duncan (1961) concluded that performance on the two-string problem could not be influenced by training procedures which provide non-specific transfer. Clearly, the instructional materials employed in the present study do not provide for specific transfer to the two-string problem. Therefore, the validity of Duncan's assertion is tested.

The present authors assume, with Maltzman (1960), that there is no fundamental difference in the behavioral principles determining creative performance and problem-solving behavior as represented in the two-string problem. Both involve the evocation of relatively uncommon responses, otherwise the situation would not be called a problem or the behavior creative.

In this regard it is instructive to note the classification of problem-solving tasks by Davis (1966). Davis classifies problem-solving tasks into two categories (Type O and Type C) based on whether trial-and-error behavior involved in their solution is overt or covert. Type O problem-solving tasks have a more readily identifiable implicit trial and error aspect. Type C problems can be solved by covertly testing and rejecting response alternatives without recourse to overt responses prior to demonstrating problem solution. Among the dimensions differentiating Type O from Type C problems, Davis notes that, given the absence of specific training in problem solution, transfer is a critical determiner of performance in Type C problem solving. Insight problems (of which the two-string problem is an instance) are classified in the Type C category. It follows from the Davis analysis that if the programed-instructional materials employed in this study sensitize the pupil to the use of skills he already possesses, as Covington and Crutchfield suggest, and if there is a great degree of generalization of the skills strengthened by the program, then the two-string problem would seem to be an appropriate test of such transfer.

Method

Subjects

The total subject pool consisted of 136 eighth-grade students in ten classes of six junior high schools in upstate New York. Five of these classes had been randomly assigned to an instructional treatment condition and five to a noninstructional treatment condition in connection with a different investigation (Ripple & Dacey, 1966). For purposes of the present study, 25 students were randomly selected from among the five instructional classes and 25 students were randomly selected from among the five noninstructional classes. *Ss* in each group were compared on pretreatment verbal creativity scores and on scores from the Lorge-Thorndike Intelligence Test, Level 4, Form A, Verbal Battery (1954). The two groups did not differ significantly on either set of scores ($p > .05$, two-tailed test).

These *Ss* were administered post-treatment paper and pencil verbal creativity tests and individual tests of a behavioral version of the two-string problem. The remaining *Ss*, 36 in the instructional-treatment classes and 50 in the noninstructional-treatment classes, were administered paper and pencil tests employing a pictorial representation of the two-string problem.

Procedure

Classes containing the *Ss* were randomly assigned to instructional and noninstructional-treatment conditions during the fall semester of 1965. After random assignment and prior to receiving instructional or noninstructional treatment, verbal creativity tests and intelligence tests were administered to *Ss*. During March and April of 1966 *Ss* in the instructional-treatment classes received ten programed-instructional lessons, one on each of ten consecutive days, in their regularly scheduled English class period. *Ss* in noninstructional-treatment classes followed the regular curriculum in their English classes during these ten days. The paper and pencil tests of verbal creativity were administered to *Ss* in all classes during the English period immediately following the last day of the treatment condition. Twenty-five *Ss* in each of the two treatment conditions were individually administered the behavioral version of the two-string problem immediately after the paper and pencil tests of verbal creativity. The paper and pencil version of the two-string problem was group administered to the 36 *Ss* in instructional-treatment classes and the 50 *Ss* in noninstructional-treatment classes immediately after the paper and pencil tests of verbal creativity.

Instructional Materials and Data Gathering Instruments

The instructional material used in this investigation consisted of a set of ten programed lessons. Each lesson contained approximately 30 full-page frames presented in booklet form. These lessons, designed by Crutchfield and Covington (1965), were adapted by the junior author from the sixth- to the eighth-grade level. The original Crutchfield and Covington programed materials were packaged in 16 lessons in booklet form and presented by cartoon illustration with an average of 30 pages per lesson. They consisted of a series of mystery and detective stories which required pupils to solve problems involving insight, hypothesis formulation, complex transformation, searching, evaluation, and discovery. Under the self-pacing, step-by-step guidance of the program, the pupil practices and is gradually strengthened in cognitive skills central to the creative process—generating many ideas, thinking of uncommon ideas, reformulating the problem, using subtle cues to discover solutions, and so forth.

The adaption of these materials, as used in the present study, differed little from the original version. Since each of the original 16 lessons contained a complete episode, the six lessons that were most redundant and/or least appropriate for eighth-grade students were easily eliminated. In all other aspects, with minor exceptions, the adapted lessons were identical to the original ones. That the shortened version of the set of lessons should not be interpreted as critical is supported by the fact that Covington and Crutchfield (1965) found significant differences between instructional and noninstructional groups on internal criterion tests administered to their *Ss* after lessons four and ten. Students in the present study were exposed to one of the ten lessons on each of ten consecutive school days in their regularly scheduled English period. Students worked through the lessons on their own, with minimum guidance from their teachers.

Standard scores from the Lorge-Thorndike Intelligence Test, Level 4, Form A, Verbal Battery were used to demonstrate pretreatment equivalence of the instructional and noninstructional groups in verbal ability. This instrument has a reported test-retest reliability of .87.

Development of the verbal creativity tests used in this study is reported elsewhere (Ripple & Dacey, 1966). The battery of verbal creativity tests consisted of four subtests measuring flexibility, originality, fluency, and imagination. A brief description of each test and the scoring procedure follows. The first three tests were adapted from the Minnesota Tests of Creative Thinking, Verbal Form A (Torrance, 1962) and involve a single stimulus—a picture of an elf staring into a pool of water: (a) Asking Questions . . . *Ss* ask as many relevant questions about the picture as they can in five minutes. The test is scored for *flexibility*—one point for each different predetermined category into which *Ss*' questions fall; (b) Guessing Causes . . . *Ss* list as many causes of the elf's behavior as they can in five minutes. The test is scored for *originality*—from zero to two points for each response, depending on the predetermined statistical rarity of the response; (c) Guessing Consequences . . . *Ss* suggest as many relevant results of the action in the picture as they can in five minutes. The test is scored for *fluency*—one point for each relevant consequence listed; (d) Imaginative Story . . . *Ss* write as imaginative and divergent a story as they can about a picture resembling a cat and a box. Stories are scored for *imagination*, from zero to two points on each of 11 factors typically found in creative stories. The scoring system for this test was adapted from Torrance, Peterson, and Davis (1963). In addition to the four tests of verbal creativity, a total score for the battery was obtained for each *S*. The verbal creativity tests were scored by five Cornell University students majoring in English. Interscorer reliabilities ranged from .74 to .96. The same battery as for the posttreatment measure was used to demonstrate pretreatment equivalence of the instructional and noninstructional groups.

A description of the presentation of the behavioral version of the two-string problem to the 25 *Ss* in each of the two treatment conditions follows. *Ss* were taken individually from their classrooms to a different room in the school building. In this room, two strings of equal length (approximately nine feet long) were suspended from the ceiling. A distance of 14 feet separated the strings. A rat trap, a vice-grip pliers, and a spring-type clothes pin were given to *Ss*. They were told that they could use any of these objects in solving the problem (tying the two strings together), but these were the

only objects they could use, and only one object could be used at a time. *Ss* then proceeded to work on the problem. If *S* had not solved the problem in 15 minutes, *E* ended the test and demonstrated the solution. Two scores were obtained for each *S*. If the problem was solved, *S* received a score of one; if the problem was not solved, *S* received a score of zero. Also, with the aid of a stop watch concealed in his pocket, *E* recorded time to solution (to the nearest second) for each *S*. If *S* had not reached a solution in 15 minutes, a score of 900 seconds was recorded.

The paper and pencil pictorial version of the two-string problem was presented to the remaining 36 *Ss* in the instructional-treatment classes and the 50 *Ss* in the noninstructional-treatment classes in a classroom setting. These *Ss* were given a picture of the two-string problem and the three objects which could be used to solve it. *Ss* were instructed to raise their hand when they felt they had reached the solution. *E* checked the answer, and, if it was correct, recorded the time to solution. If incorrect, *S* was instructed to continue. Again, *Ss* were allowed 15 minutes to solve the problem. The same two scores were recorded for these *Ss* as for those *Ss* who received the behavioral version of the two-string problem.

Results

The cumulative frequency for the 25 *Ss* in each of the treatment conditions reaching solution in the behavioral version of the two-string problem is presented in Table 1. It can be seen that the number of *Ss* who solved the problem is greater in the instructional treatment than in the noninstructional treatment at all time intervals.

Table 1. Cumulative Frequency of *Ss* Reaching Solution in the Behavioral Version of the Two-String Problem

	Cumulative Frequency in One-Minute Intervals														
Treatment[a]	1	2	3	4	5*	6	7	8	9	10	11	12	13	14	15
Instructional	4	7	9	11	14	16	16	16	17	17	19	19	19	19	20
Noninstructional	0	2	3	5	5	8	10	10	12	14	16	16	16	16	19

[a] $N = 25$ in each treatment
*$p < .05$ (Kolmogorov-Smirnov test of goodness of fit)

Two statistical tests were used to treat these data. The Kolmogorov-Smirnov test of goodness of fit (cf. Guilford, 1965, p. 260) was used to determine if the treatments yielded significant differences at any particular time interval. A significant difference favoring the instructional treatment was found at the five-minute interval ($p < .05$). The difference between treatment conditions on time to solution (in seconds) was tested for significance with a t test. Table 2 shows that the mean of *Ss* in the instructional treatment was significantly smaller than that of *Ss* in the noninstructional treatment ($p < .05$). That is, *Ss* in the instructional treatment solved the problem faster than *Ss* in the noninstructional treatment.

Table 2. Means, Standard Deviations, and t Ratio for the Two-String Problem[a]

Treatment	Mean	S.D.	t
Instructional[b]	387.48	333.29	1.84*
Noninstructional[b]	549.24	283.90	

[a] Numbers represent time to solution in seconds
[b] $N = 25$
*$p < .05$ (one-tailed test)

Table 3 presents data for the same *Ss* on the flexibility, originality, fluency, imagination, and total scores of the verbal creativity battery. None of the t ratios reached significance.

TABLE 3. MEANS, STANDARD DEVIATIONS, AND t RATIOS FOR POST-TREATMENT VERBAL CREATIVITY BATTERY

Test	Treatment[a]	Mean	S.D.	t
Imagination				< 1
	Instructional	8.92	3.64	
	Noninstructional	8.84	4.47	
Flexibility				< 1
	Instructional	6.40	2.27	
	Noninstructional	6.60	2.63	
Originality				1.21 n.s.
	Instructional	5.20	3.69	
	Noninstructional	4.08	2.80	
Fluency				< 1
	Instructional	9.96	4.47	
	Noninstructional	9.28	4.09	
Total Score				< 1
	Instructional	30.88	10.32	
	Noninstructional	28.80	7.97	

[a] N = 25 in each treatment for each test

Table 4 shows data comparing per cent of solutions of the two-string problem and mean time to solution for the 50 *Ss* receiving the behavioral version of the two-string problem and the 86 *Ss* (36 instructional, 50 noninstructional) receiving the pictorial version of the two-string problem. Although these data are presented only descriptively, it is interesting to note that within each presentation condition the per cent of solutions for instructional and noninstructional treatments are approximately the same. For both per cent of solutions and mean time to solution, *Ss* receiving the behavioral version of the two-string problem are superior to those receiving the pictorial presentation.

TABLE 4. PER CENT OF SOLUTIONS AND MEAN TIME TO SOLUTION ON THE TWO-STRING PROBLEM FOR METHOD OF PRESENTATION AND TREATMENT

Treatment	Method of Presentation	
	Behavioral[a]	Pictorial[b]
Per cent of Solutions		
Instructional	80	42
Noninstructional	76	44
Mean Time to Solution[c]		
Instructional	387.5	666.6
Noninstructional	549.2	684.4

[a] N = 25 in each treatment
[b] N = 36 in instructional treatment and 50 in noninstructional treatment
[c] Numbers represent time to solution in seconds

DISCUSSION

Of those *Ss* receiving the behavioral version of the two-string problem, the *Ss* in the instructional treatment solved it significantly faster than did those in the noninstructional treatment. Although it appears that most eighth-grade students can solve the two-string problem (given the form of it that was used) within the 15 minutes allowed, more instructional-treatment *Ss* than noninstructional-treatment *Ss* solved the problem sooner. It would appear that the chief advantage gained from the programed instruction employed in this study is the speed with which the two-string problem can be solved. In this sense, the present study is in disagreement with Duncan's conclusion that performance on the two-

string problem cannot be influenced by training procedures which provide nonspecific transfer. It also differs from findings reported in a study by Anderson and Anderson (1963). Using a brainstorming technique, Anderson found that such training did not transfer to insight problems—one of which was the two-string problem. Anderson did suggest that more intensive training or training of a different sort than he employed might result in such transfer. The present study yields data that support this suggestion. Limited by the nature of the advantage gained from instruction, as stated above, this study also supports the contention by Covington and Crutchfield regarding the transferability of the direct training of generalized problem-solving skills.

Comparing the per cent of and time to solution in the behavioral and pictorial versions of the two-string problem regardless of treatment condition, it is of interest to note the striking superiority of *S*s in the behavioral version. Apparently the fruits of transfer gained by *S*s in the instructional treatment are capable of being exercised in the behavioral version but not in the pictorial representation. This finding remains a puzzling one to the authors.

Regarding results from the verbal creativity battery, the present study does not confirm the findings reported by Covington and Crutchfield with fifth- and sixth-grade pupils. It will be recalled that in their study the instructional effects were less potent at the sixth- than at the fifth-grade level. In the present study the lack of significant differences on measures of verbal creativity suggests a further diluting of the effects of these programed-instructional materials on verbal creativity at the eighth-grade level. It is likely that as grade level is increased, more challenging and/or differently oriented programs will be needed to capture the optimally facilitative effects of programed materials on verbal creativity and problem solving behavior.

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